

Rand
SANTA MONICA, CA. 90406

October 7, 1985

NRO Review Completed.

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OD&E

Central Intelligence Agency
Washington, DC 20505

Dear Don:

Since your visit to Rand, I have received several reprints of early and unclassified Rand publications. Enclosed with this letter please find copies of the following:

- (1) The First Project RAND Report, SM-11827, *Preliminary Design of an Experimental World-Circling Spacecraft*, May 2, 1946, with key chapter by Louis Ridenour, chapter 2.
- (2) J.H. Huntzicker and H.A. Lieske, *Physical Recovery of Satellite Payloads -- A Preliminary Investigation*, Research Memorandum RM-1811, 26 June 1956. This work may owe its inception to prior work of Richard Raymond, and may have been influenced by the spring 1956 analysis of ICBM costs by M. Margolis (an internal Rand document that I am unable to release).
- (3) Carl Gazley, Jr. and David J. Masson, *A Recoverable Scientific Satellite*, Rand Paper P-958, October 5, 1956, revised in February 1957. Carl Gazley had come to Rand from GE, and contributed to his colleague's understanding of ablative materials and capabilities to protect payloads. A radio tracking and beacon system is proposed.
- (4) S.M. Greenfield and W.W. Kellogg, *Inquiry into the Feasibility of Weather Reconnaissance from a Satellite Vehicle*, Report R-218, April 1951 (FOR OFFICIAL USE ONLY).
- (5) Amrom H. Katz, *Hiders and Finders*, Paper P-2432, April 26, 1961.
- (6) Amrom H. Katz, *Observation Satellites: Problems, Possibilities and Prospects*, Paper P-1707, 25 May 1959.

Sincerely,

Bae

William R. Harris

WRH:zs

Enclosure: As noted above.

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Colonel C. F. E. Oder
Ballistic Missile Division

Dear Fritz:

In our efforts to help you in the current crisis over SAMOS we have talked, listened, and thought a lot. Our first cut in answering you turned out to be a very rumbling argumentative personal history and analysis of SAMOS. That document may have a charm and utility all its own, but it didn't really tell you what to do now. Hopefully this letter will contain some positive suggestions.

As we see it it is your task to make the program:

Relevant by getting proper requirements in proper time,

To make the program acceptable by thinking out suitable political action,

To make the program workable by using sound ideas, obtaining good engineering, and getting a lot of good, hard work done.

To make the program invulnerable both physically and politically.

The kinds of ideas which we can contribute to you at this date divide, naturally, into three classes:

1. Suggestions regarding alternative satellite programs, new camera-vehicle combinations, new sources, etc.
2. Quick-fix ideas: what to do or try to get done in the existing programs under existing contracts.
3. What to do for follow-on long term programs: what R&D to initiate, what to think about for future Recce satellites.

NEW IDEAS WORTH TRYING

There are two main notions that govern our thinking about new ideas:

- I. Recovery is of such dominating importance that it simply must be made to work.

Backup programs must really be alternatives, not duplications and not parallel programs.

We have previously and informally suggested several ideas worth considering and evaluating in connection with recovery as presently planned. These ideas are briefly restated:

1. Assorted ideas and suggestions of possible use in recovery.

a. Radar tracking of the incoming bird. It seemed to us in 1957 that we must get a firm handle on the trajectory. From what we are able to make out of the DISCOVERER program this is a deficiency. We have never established the reason for non-radar tracking; we must assume that it was considered at one time and rejected. On the other hand it seems worth considering again.

2. b. We have discussed informally the notion that in an effort to increase the ^{TIME}SWATCH for the aircraft recovery phase of the operation, it might be desirable to have the package floating at a constant altitude. This could be done by popping a balloon. Such systems have been developed for deployment from high speed aircraft.

c. For numerous good and sufficient reasons we are beginning to think that continental recovery is preferable to water recovery. This would certainly minimize the chance of non-U.S. citizens picking up the package and would maximize the search time. In connection with notions about continental recovery it might be worthwhile to have a study made of air traffic routes in the U.S. and of traffic densities. It is not at all unlikely that we could find some fairly sizeable area to operate which would by its very choice minimize interference with commercial air traffic. Clearly a good part of Canada furnishes an example. The previous remarks were addressed principally to recovery within the 48 of the U.S.

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d. The present DISCOVERER recovery technique seems to us (hopefully we're wrong) to run into certain difficulties at the time it re-orients preparatory to ejection from orbit. A possible way to avoid a lot of this maneuvering is to install the retro-rocket at the angle required for ejection and not re-orient the bird at all.

2. The second main idea having to do with recovery is associated with the word SPIN. It turns out that several U.S. satellite and space shots and several non-U.S. shots have been spun - except DISCOVERER. We are suggesting a good look at spin once again. We are well familiar with the fact that new and attractive ideas which are as yet untested may seem to have fewer bugs than those ideas which are actually being tested. With this as an apology, let us attempt to compare spin recovery system with the operation of DISCOVERER. We are, of course, talking about launching a spin stabilizing satellite whose original spin orientation is chosen both for the operational mission and for recovery orientation. Recovery is simply initiated by pushing a button at the correct point in the orbit. The satellite is in the correct orientation. Compare this with the DISCOVERER sequence: after getting on orbit turn 180° around a vertical axis, fly straight and level, then in preparing for recovery dip down 60° or so, spin up, separate, and fire away. Recovery from this spin mode seems so attractive to us that we are urging it as an alternate backup recovery program. We think it important enough to merit several early shots to test recovery only.

II. New Useful Camera Combinations.

1. The most interesting thing we heard recently was the HYCON story about the 36" focal length, 18 x 18 camera. Although they were talking about this as a basis for E-5 we find ourselves more interested in this camera almost as it is. We found the photographs which they had made with this camera extraordinarily persuasive. This is another way of saying that a contact print in the

hand is worth three designs in the bush. This camera requires stabilization of the SAMOS variety. It strikes us as likely that there are other cameras of this general type that we may not yet be thoroughly familiar with. (You will recognize that the reasons for this are not apathy or lack of diligence on our part.)

2. The next single interesting idea is a revival of our 1957 spin-pan camera system. We are neither so foolish as to think that an idea that was good in 1957 is necessarily good in 1960, nor so smug as to not realize that lots of changes have been made since 1957. Let us look briefly at the constraints which made that suggestion look good at that time. The spin-pan camera system seemed to provide a solution to the attitude control program with a simple design of a panoramic camera and to the entire recovery concept. Since that time AGENA has become available and DISCOVERER has been stabilized successfully and often. On the other hand, as we noted previously, spin stabilization has also worked remarkably well, recovery has become much more important than it was at that time and backup programs are needed. Further (as we discussed at length in the long diatribe referred to earlier) many people who know as much as they have been able to find out about SAMOS and who realize that recovery is No. 1 priority think it incredible that the first scheduled recovery reconnaissance system is E-5. It is from these considerations that we think the spin-pan system should be looked at again. The kind of specs that we would call out now are not the same. In 1957 we urged that the first development be a 12" focal length camera which at modest and attainable resolutions of 40 lines per millimeter would have yield ground resolution of approximately 60'. This modest comparison of numbers was a very tight function of the modest payload we had at our disposal. Fortunately, things have changed in this department also. More payload is available and it is not out of order to talk about a 36" spin-pan system which, starting out with fast film and modest resolution goals, could be beefed up to use the popular slow high resolution films

and eventually to ground resolution numbers on the order of 12'. It is this particular suggestion which we want you to consider when you read the separately communicated appendix written by C. Heffern. The reason we are putting this in a separate appendix is based on potential security implications; the RAND audience for Heffern's idea has been verbally controlled in anticipation of a favorable evaluation by you. Hence no more will be said about that ideas in this letter.

Note: The following two suggestions for possible improvement of DISCOVERER in different modes are due principally to John Huntzicker.

3. Discoverer "T". The Air Force could within the next year launch a couple TIROS satellites into polar orbits, using the Thor-Agena combination. (In fact the Thor-Agena-B has a capability to launch the TIROS and then go on to perform some function of it's own liking.) There exist a number of reasons for looking upon this particular operation with favor, these are discussed below.

The Air Force has a very real present and future use for the cloud cover data that the TIROS can produce. This would be an economical way to get their feet wet and see how best to use this data, how to fit such a system in operationally, how to plan future cloud recce systems, etc..

The Air Force may find that future intelligence gathering missions may critically depend on having a good cover story. There is no better cover than one which is true to a considerable extent. Later versions that contain high resolution recce gear might continue to carry TIROS type equipment which would give continuing evidence that the operation is a cloud recce system. If the satellite were a photo-recovery type the TIROS gear could be left in orbit, it might be hard to prove that anything had been returned to earth. The TIROS equipment could be designed to fail on a regular basis to defend frequent launchings. (We could call in those experts of planned obsolescence, the American auto designers, or even better the makers of batteries guaranteed for 36

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months that fail at 37.)

The techniques and practice of launching spin stabilized satellites from the DISCOVERER would be well developed by this early program.

4. A More Versatile Agena-B Platform. It appears to be highly desirable for the Air Force to develop the Agena-B into what the Lockheed ads have been implying for some time, i.e., an all-purpose satellite stage. This would mean a departure (maybe reluctantly) from the highly integrated "systems" approach to all of the payload installations. This development would take two forms;

- a) Developing the Agena into a boosting stage, whereby the final orbiting stage is detached (a la TIROS) and the last propulsive stage discarded.
- b) Developing the ability within the Agena to accommodate a modest spectrum of semi-integrated payloads. Possibly utilizing the Agena's ability to furnish attitude stability, and maybe retro-impulse, but preferably furnishing its own power, communication, etc. It is important to have as little of the payload as possible that needs to be checked out as a part of the Agena stage, hopefully the horrendous time spent in mod and checkout (6 to 7 months) can be cut down somewhat.

This suggestion isn't an adequate response to the current requirement placed on the program, but it is not reasonable to expect that this is the last time that the program will find itself enveloped in urgency. It is believed that the development of such a capability would make itself felt within a year or so.

It seems a little restrictive for the SAMOS program to insist that all future recovery payloads necessarily accommodate to the recovery package being developed for the embryonic E-5 payload.

One of the more apparent areas with the SAMOS program that could be exploited for an extended and early capability is the DISCOVERER series.

(It might be argued that they are actually two separate programs, the differences

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are primarily of a bookkeeping and publicity nature.) The advantages are attractive:

- a) There exists a schedule for launches and boosters and Agena stages are at least tentatively allocated. So it would seem that some of the obstacles to rapid exploitation are already passed.
- b) Because the DISCOVERER is Thor boosted there will be no interference with the Midas program insofar as launch facilities are concerned.
- c) The excessive publicity given to the DISCOVERER to date could help considerably as a cover. It is well characterized as a research vehicle with limited payload (if we can only keep our mouths shut over the increased capability of the Thor-Agena-B).

The Thor-Agena-B combination can place better than 1000 lb in a low altitude orbit. Let us postulate a photo-payload with the following rough characteristics -

Altitude.....	160 n m
Lifetime (operating).....	1 week
Data return.....	recovery
Focal length.....	35"
Format.....	9" x 9"
Total take.....	9" by 6,000'

From this we might arrive at the following gross weight breakdown:

Electrical power.....	200 lb
Attitude control (incl. gas)....	150 lb
Camera <u>plus</u> film	250 lb
Recovery capsule and aids.....	150 lb
Retro rocket.....	200 lb
Contingency	50 lb
TOTAL	1000 lb

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A possible design concept is to have the DISCOVERER fly contentiously in a horizontal attitude, package the camera optics, supply reel and retro rocket between the tanks and capsule, which would contain the take-up reel. This involves taking via a mirror which would be used for IMC and oscillate between three positions for increasing the swath width. The motions would not be prohibitively fast, taking three pictures in 8 seconds, tilting the mirror $14\frac{1}{4}^{\circ}$ between exposures. The yield will be about 50 swaths across Russia, each about 120 n m plus in width. This consumes about 6,000' in one week and the territorial yield is about 10^7 (n m)². It is assumed that the film would be wound into the capsule and only the film returned. The camera is a particularly bulky item to return and the economies are dubious.

At 160 n m altitude and with a 36" lens the effective ground resolution would be about 17.5' with a 60 line/mm performance in the camera, and about 26' with 40 mm. The selection of 160 n m was a nominal selection and a little arbitrary, it could be lowered somewhat but not enough to buy a lot in resolution. The design period (adjusted through the apogee) would be selected to minimize the overlap between successive passes (an offset of 2° day) or to maximize overlap if the desire is to maximize the probability of covering a particular subset of areas. Orbits inclined to about 65° to 75° would be interesting in their ability to maximize coverage at those latitudes but the most desirable launch directions are not readily available (northeastward or southeastward).

As a general wrapup comment to this section of new ideas, we suggest that it might be desirable not to have all new ideas automatically funneled through and be allocated to Lockheed. Competition is a great idea but it required more than one company to see beneficial results follow.

QUICK-FIX

Most of the ideas we have today which could be classified under the title at the head of this section have been communicated in one form or another over an extended period to the SAMOS project office. Very briefly and because detailed exposition does not seem necessary, they are:

1. E-1. We feel very strongly that the F-1 stuff should be taken out of the E-1 package in order not to compromise chances of success of the E-1. E-1 should fly just as soon as possible. Next, Eastman should be asked to pick an average focus and an average IWC setting, then the controls should be locked, the key should be thrown away and conversation with the machine should be minimized. What we would be shooting for here is an initial and small success. Next, a hurry up investigation should be made of the feasibility of installing a frame camera with its own shutter in the E-1 and E-2 birds, thus getting rid of the strip camera. I now have the general impression that somebody is stalling on this subject. I have been hearing for a long time that this is being investigated and I now suspect that this is an investigation designed to forestall any action. Instead we want an investigation that should produce some action. The cameras I have suggested for this mission are the P-2, P-220, or similar type. Strangely enough at the latest Lockheed briefing, the Lockheed people had not yet heard of either of these (now comparatively ancient) cameras.

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THREE GROUPS OF PROBLEMS FACING YOU

The first kind of problem which has been getting most of the attention so far is a straight forward reconnaissance problem, having to do with requirements, use, design, and other reconnaissance sensor part of the SAMOS.

The second kind of problem has to do with everything else in the system, boosters, controls, operations, stabilization, power supply, communication equipment, etc.

The third kinds of problems have to do with political acceptability and palatability and vulnerability. We will shortly have something to say about matters in each of these groups of problems. We cannot pass on to the next point without inserting a point which you will find either bolsters your opinion or is intensely arguable. This has to do with the report entitled "SAMOA" which we heard Lockheed present to you a few days ago. The four of us from RAND who attended this briefing could not help but come to the opinion ^{THAT IT} was a willfully weak and fell many orders short of the requirements that were called for by the urgency and importance of the

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VULNERABILITY-POLITICAL AND PHYSICAL OF RECONNAISSANCE SATELLITES

There are three reports which we know of which treat some aspects of the matters subsumed under this heading. The first is a report on WS-117 vulnerability from Lockheed dated 30 September 1959. It is presumed that this is available to you and we will say nothing further about this. The second is the document entitled U.S. Political Action for Reconnaissance Satellites prepared by Mr. Richard S. Leghorn on January 8, 1960 in Washington. We believe that you have this document.

The third document is one recently prepared at RAND in response to a request by General White, it is entitled "Defense Against Possible Soviet Antisatellite Warfare". (See) RM-2588 dated June 1, 1960. This report can be made available to you if you so desire.

We mention briefly several ideas which should now appear to be in any of the several references cited immediately above. The first with respect to physical vulnerability. Vulnerability is always preceded by detectability. If the satellite can not be detected it is essentially invulnerable. There are several ways to minimize detectability. One of these is emphasis on short life. We do not know at this point

Notes on a meeting at RAND on Thursday evening

July 7, 1960.

For Secretary

In attendance: E.C. Heffern, J.H. Huntzicker, A.H. Katz of the RAND Corp. and Fritz Hartwig, Reuben Mettler, and George Solomon of Space Technology Laboratories.

*Katz suggested that will exp
in consultant for STL*

Background: In response to a direct request from AFBMD, RAND has been working with them in formulating a plan for augmenting the Air Force satellite reconnaissance program to furnish a high confidence of early useful output. A number of possible courses suggested themselves, that maximize the utilization of already developed components, facilities, programs, etc. all of which had the features of being simpler than the 117L program and being competitive in time. The recommended program was based on the philosophy embodied in RM 2012 (maximum simplicity using spin stabilization to aid in the photographic and recovery phases) but with the new feature of using a standard Atlas booster and an additional stage that resembles in outward appearance a weapon re-entry shape. The security of the entire operation would be a maximum, few people would have to know that the shots were anything other than a standard Atlas test shot.

Apparently the Air Force bought this last mentioned recommendation. On the 7th Amrom received a call from Col. Worthman (special assistant for security to Gen Ritland) saying that this particular program was becoming "very black" or of highest sensitivity security-wise. He stated that STL had been directed to study this suggestion and that Reuben Mettler would contact Amrom - and - that Gen Ritland would appreciate RAND's giving him all the assistance that we could . Due to the secure nature of this activity he suggested

that Katz be the only individual at RAND to know of it.

Katz insisted that Heffern and Huntsicker already were knowledgeable and would need to be included if we were to be of maximum help. The initial meeting was set up for the evening of the 7th. Those listed above were in attendance.

Discussion: Dr. Mettler explained that STL had been given a contract to study the program suggested by RAND(as of the 1st of July they qualify for such contracts). This was to be a 30 to 40 day study wringing out as much of the technical detail as is possible, but emphasizing a laying out of the effort, scheduling, expenses, etc. that would be involved. Col Evans indicated to Mettler that he felt that the money would be available for such a program. On questioning Mettler indicated that STL hoped that their work might be thought of by the Air Force as a proposal, they (STL) would certainly submit a thorough technical study but would also propose (separately?) themselves as an organization to undertake the effort. They thought of the program as resembling the effort connected with Project Score insofar as security is concerned. A group of about 6 people at STL would be all that would know of this effort at present.

Katz reviewed our thinking related to the suggested program. Beginning with RM 2012 the advantages of spin stabilization were related to the simplicity of maintaining attitude for the photographic phase and also for the recovery phase, once the initial spin up and injection is accomplished the rest comes automatically with no further activity and more important - no further chance for foul-up and failure.

From this he progressed to our thinking relative to the aforementioned reconnaissance satellite program augmentation. The points

emphasized here were that the program should be simple, use existing vehicles, and be truly complementary to the Samos program in that it would utilize alternate philosophy and techniques. This suggests a simple vehicle, including stabilization, communication, ground facilities, etc. It suggests physical recovery for data retrieval and to maximize the advantages of recovery it suggests using a high rate of data acquisition as opposed to a payload furnishing fine detail of selected areas (this is the goal of the Samos E-5).

In detail the program used a stage for the Atlas that physically resembled an advanced re-entry shape. It would be launched by a standard Atlas southward from PMR. Precise guidance would be in the Atlas stage with only 1,000fps being added by a small rocket in the orbiting stage. The vehicle would be spin stabilized with an attitude horizontal at about 55° N lat. in daylight. It would operate for two days and then fire a retro rocket and return the film to earth. The specs would be - an altitude of about 142 miles, an

initial wt.	1500#
focal length	36"
Film size	5" x 15,000ft (thin base)
camera mode	panoramic using spin of vehicle
effective ground resolution	17ft
recovery	surface, land or sea